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ABSTRACT

Many consider the use of adjunct questions (mathemagenics) to be a means by which the instructional value of a text can be increased with relatively little difficulty, and this explains the appeal they have generated over the years. Yet this appeal is seldom tempered by a consideration of the ecological validity of the experimental studies on which the theoretical foundation of mathemagenics is based. The issue is whether the research evidence for enhanced learning that is obtained in controlled studies can be extrapolated to practical instructional settings. It is mainly the effects of postquestions that create the most interest, for it is they which enhance both relevant (question-related) learning and incidental (unrelated) learning, as seen on a posttest. In experimental studies, the students cannot turn back to seek out or check the answer to the question they have just encountered. Their only option is mental review, which is a far different situation than the one encountered in practical settings where students study freely with their textbooks. Experimental constraints also encourage students to process the text in ways that are an exaggeration of their natural techniques. Thus, both mental review and the general stimulatory effect of postquestions are confounded by procedural tactics. The procedural paradigm currently employed in mathemagenic research will not provide useful and practical results. That postquestions do enhance learning in real study settings is generally recognized. However, how they do it and how questions can be best used remains to be established. (HOD)

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Occasional Paper 1

ADJUNCT QUESTIONS EFFECTS AND EXPERIMENTAL CONSTRAINTS

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Adjunct Questions Effects

and Experimental Constraints

> Narrow theories that deal only with artificially limited data sets are of no interest, however parsimonious they may be, if it can be shown that they are insufficient to deal with the general problem.
>
> - Kintsch (1974, p. 201)

Ever since Rothkopf stimulated interest in the possibility of enhancing prose materials through the use of adjunct questions (Rothkopf, 1965), the research in this particular area of instructional psychology has grown phenomenally. Interest in the field of education seems high, as evidenced by the growing number of reviews devoted to this topic in the literature. Mathemagenics furthermore, are entering the educational psychology textbooks, at least in theory, if not yet very often in practice.[1]

Mathemagenics are usually thought of as means by which the instructional value of a text can be increased with relatively little difficulty and this, indeed, would explain the appeal they have generated over the years. Yet this appeal is all too seldomly tempered, it would seem, by a consideration of the ecological validity of the experimental studies on which the theoretical foundation of mathemagenics is based.

The issue is an important one for educational practice: can the research evidence for enhanced learning which is obtained in controlled studies be extrapolated to practical instructional settings? What must be considered is whether the experimental task constraints employed in the controlled studies mirror the constraints operating in real-life settings. It is the intent of this paper to

discuss this issue and to argue that a practical case for certain mathemagenic effects remains to be made. It is not its intent, however, to offer yet another detailed review of the literature in this area.

Procedural Constraints

The adjunct question paradigm is a well-established one: questions are interspersed throughout a prose passage or short text in one of two positions: either close before the text material to which they relate or shortly after that material. It is mainly the effects of postquestions which create the most interest, for it is they which enhance both relevant (question-related) learning and incidental (unrelated) learning, as seen on a posttest. What is of concern to us here is the procedural paradigm which pervades this research area. This is as follows: the students participating in the study read the prose passage page by page until they encounter a postquestion, which is placed on a separate page; after attempting to mentally answer the question, they then proceed to a further segment of text and so on. The important procedural point which sets these experimental studies apart from their corresponding practical context is that physical review of the text is not permitted. In other words, the students cannot turn back to seek out or check the answer to the question they have just encountered. Their only option is mental review.

Such a procedural paradigm is fine if one is interested in the effects of mental review, but that is a far different situation than the one encountered in practical settings, where students study freely with their textbooks. There are, it is true, some settings such as in computer-managed instruction (cf. for instance, Anderson et. al. 1974) where review is explicitly prevented, but these are relatively specialized settings, quite unrepresentative of natural study settings. Furthermore, the ecology of these specialized settings give the postquestions the character of a quiz rather than one of a set of learning aids.

An anecdote from another area of instructional psychology illustrates how task constraints can readily influence outcomes and modify the ecology of the setting. Anderson and his colleagues (cf. Anderson, 1970) asked why it was that the provision of prompts in programmed instruction sometimes hindered learning rather than facilitate it, as was certainly the expected outcome. What they found was that their particular program inadvertantly enabled the students to answer the questions by directly going to the prompted information without fully processing the frame. It was not that their students were cheating, but rather that they were going through the text in a different way than expected. They were simply processing the text differently. A similar situation would seem to prevail in mathemagenic research: experimental constraints encourage students to process the text in ways which are an exageration of their natural ones.

There is little empirical analyses at the appropriate level of the reading strategies adopted by students as they process a prose passage. In one of the few such studies, Thomas and Augstein (1972) found that effective reading strategies could involve the students in frequent returns to earlier segments of text in order to check or complete their understanding of particular points. This is exactly the type of text processing which inserted post-questions can be expected to favor when encountered in natural settings.

To my knowledge, relatively few researchers have conducted mathemagenic research where physical review of the material was permitted after the student encountered a post-question. Washburne (1929), Gustafson and Toole (1970), and Hiller (1974) have done so and their results would lead one to view the issue of extrapolation to practical settings with some diffidence. These researchers allowed their subjects to adopt a free reading strategy by enabling review of prior material after encountering inserted post-questions. In all three studies, post-questions generally failed to enhance incidental learning, as they usually

do with the traditional but less naturalistic paradigm, and in some conditions of the Washburne and Hiller studies, incidental learning was even depressed. In these studies then, post-questions would seem to have shaped a selective learning strategy, whereby attention is focused primarily on question-related content, sometimes to the detriment of other content.

Part of the problem is that mathemagenics, as they are operationalized in current research, are attractive to researchers for their practicality in terms of procedural design. Frase has noted before (1973) the force which an emerging methodology can have in molding a relatively new field. The result seems to be that mathemagenics have become established as a specialized field of research of intrinsic interest of itself and eventually more and more remote from practical considerations. This reflects the fate of many issues in the history of psychology and is quite understandable in terms of the traditional trade-off of external validity for tighter experimental control (Campbell & Stanley, 1963). This unfortunately is the price which must often be paid in order to guarantee strong internal validity. It also reflects, I would think, a tacit belief in a paradigmatic view of educational progress in terms of leaps and bounds through which conclusion-oriented research, as the mathemagenic research can certainly be characterized, informs practical decisions in an indirect albeit strong way (Cronbach & Suppes, 1969). however, as the earlier quotation from Kintsch would suggest, a given field of enquiry can become so narrow as to lose much of its potential impact in terms of its eventual applicability to real settings. As he also states, "explanations are proposed for particular experiments, not for the question that at one point motivated the experiments" (1974, p.201).

Mathemagenic Processing

An interesting aspect of the mathemagenic problem, if it can be called that, lies in the recent shift into a cognitive framework of explanation, which is evident in educational psychology generally, as in more fundamental verbal

learning psychology as well. Indeed, the modeling of processses has become more prominent in mathemagenics as elsewhere over the years. Rickards (1979) has recently reviewed this area to show how four distinct processes can be invoked in order to interpret the mathemagenic effects of postquestions. These have been demonstrated to have both a backward effect (i.e., on what has just been read, but which cannot be re-examined) and a forward effect, (i.e., on what will be read). Both effects, furthermore, can either be specific in nature (question related) or general (unrelated to the questions).

It is the general forward effect of post-questions which had been initially called attention to by Rothkopf and which has brought about much of the subsequent interest in inserted questions. An interpretation of this effect is that the provision of post-questions shapes the student's inspection behaviors, such that he or she will tend to gradually engage in more careful inspection of subsequent segments of the prose passage. This effect is borne out by the research which has employed the classic procedural paradigm described earlier (cf. the Rickards review, 1979). It is, however, not borne out by the three studies mentioned earlier which have allowed review of the prior material. Furthermore, an intuitive consideration of natural study settings would lead one to believe that such a process would not likely be very strong in such settings. The basic problem than is again the procedural one: prevention of back-tracking artificializes the student's reading strategies.

Thus, mental review and the general stimulatory effect of post-questions are both confounded by procedural tactics. It could only be difficulty argued, however, that these two processes are merely quirks of the procedural paradigm currently governing mathemagenic research. We just do not know what importance (or what little importance) to give to these processes in practical settings. I have indicated elsewhere (Duchastel, 1979) that the mathemagenic literature can be usefully interpreted mainly in terms of a selective learning process, with

relatively little importance accorded to other processes. In the past, we seem to have considered all processes as somewhat of equal importance. There is no need to continue doing so, however, especially if we take the procedural constraints of the field into account.

Research Strategies

The field of mathemagenic research can be considered from different perspectives. The first of these could be called the pure mathemagenics view, for it construes mathemagenics as being not directly concerned with instructional practice, but rather with the exploration of more general issues in the psychology of learning (Frase, 1973). This may seem perfectly laudable within a given framework; however, it is well worth remembering that psychology itself is littered with theories and research on learning which prove a constant disappointment outside of academia because they either fail to mirror real life settings or else they mirror relatively trivial ones. A psychology of the artificial is a luxury which we can only difficultly continue to afford. Frase (1973) himself has hinted at the potential dangers involved with such an approach.

Another perspective which can be adopted in interpreting the mathemagenic literature could be called the forced mathemagenic view. This view recognizes that certain processes may perhaps only play a minimal role in real settings. Furthermore, it is precisely because of this state of affairs that these processes need to be bolstered or "forced"; otherwise, they may not be amenable to investigation at all. This is not all that uncommon in science. For instance, in biology, cells are often stained before being examined under the electron microscope; whether this radically alters what one then sees and infers from the investigations is currently a question of debate (cf. for instance, the provocative article by Hillman and Sartory, 1977). Forcing techniques are also current in other areas of prose learning (cf. for instance, Dooling & Christiaansen, 1977, p. 7). The great danger with this view, however, because of its subtlety especially, is that

the forcing is eventually forgotten and goes unrecognized. Untempered extrapolition then becomes all too easy.

A third perspective is the ecologically valid one, where experimental constraints mirror as closely as possible natural text handling strategies. The study by Gustafson and Toole (1970) is prototypical of this approach.

In sum, of the three ways of approaching mathemagenics, the practical alternative has been rarely considered, while the remaining two (the pure and the forced approaches) have possibly fallen in the trap of running away with themselves.

Where to from here?

Both Rothkopf (1973) and Frase (1973) have opened the dialogue concerning these issues and the main purpose of the present paper is to further attempt an open discussion of these important themes. If I am right in thinking that the procedural paradigm currently employed in mathemagenic research will not provide us with useful and practical results, then it is time we reassess what we feel about the field and broaden the scope of our investigations to include procedures which more directly reflect real learning contexts.

However, one must not be bitter about the deficiencies of the past and overlook the contribution which this area of research has made to the field of instructional psychology as a whole. Mathemagenics research has indeed not only renewed the interest of educators in questions, but it has also put in more than its fair share in assisting the paradigmatic shift we have recently witnessed in psychology towards a cognitive perspective of learning.

A greater concern for what mathemagenics are especially good at (cf. Anderson and Biddle, 1975) would, I am sure, be especially useful in the future. For instance, the direct effect of questions in enhancing the learning of question-related passage content can be substantial. Also, the process of selective learning (the focusing of learning through the provision of inserted questions) needs to be explored

much further to find out when and how it can be optimized, especially in relation to complex high-level types of learning. Finally interest in the related area of posttesting effects (obtained through the provision of quizzes administered after learning) could profitably be renewed, for their practical potential would seem even greater than that of inserted questions and remains relatively untaped (cf. Anderson and Biddle, 1975).

The main argument developed in this paper, however, has simply been that we need to stop assuming that all of the post-question research findings reported in the literature can realistically inform instructional practice and textbook design. This is an assumption which continues to be made by most reviewers of the field (one notable exception is Rickards, 1979)[2]. That post-questions do enhance learning in real study settings is generally recognized. However, how they do it and how questions can be taken best advantage of remains to be established. It is my hope that researchers interested in mathemagenics will become aware of the problem and design future studies so as to seek solutions which can be of relevance pedagogically.

FOOTNOTE

1. While the term mathemagenics covers a whole host of adjunct aids, I shall use it here in a restricted sense to cover only adjunct questions.
2. Melton (1978) also discusses this issue in a paper comparing research on behavioral objectives to research on adjunct questions.

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Postscript:
Adjunct Questions in Naturalistic Settings

Note: Since writing this critique of the mathemagenic literature (about a year ago or so), I have had occasion to reflect further on the problem it raises for the research community and on what line of research may prove promising in the future. Discussion of the problem in a research seminar at the American College[1] has also been enlightening in speculating about processes underlying the use of adjunct questions in text processing. This postcript is meant to reflect these thoughts and speculations.

The principal issue raised in the paper is the apparant lack of external validity of most of the research on adjunct questions in text. The basic argument is that students in real educational settings simply do not study their textbooks in the same way that subjects in laboratory experiments do. It is not the difference in environment per se which causes the discrepancy, but rather it is the difference in task orientation. In the usual adjunct question experiment, the student is not allowed to backtract; whereas, in real academic settings, it is plausible to think that he or she will normally backtrack.

We currently know very little about what students, in fact, do while studying texts and even less about what they would do with texts incorporating adjunct questions. Hence, the speculative nature of the argument. Speculation is often seen as ungrounded, and by some as not a serious base on which to rest an argument. This I believe to be a serious mistake, for speculation can and should be an integral part of any scientific discourse. Empirical data are only one aspect of the investigation of a

phenomenon, and interpretation (which involves speculation) is really the crux of the matter.

It is interesting, therefore, to consider the processes which may be operative in the use of adjunct questions. This is, of course, at this time very speculative, but I believe it to be important, if only to map out certain assumptions, thus opening them up for further consideration and critique. What processes might occur then in learning situations which involve adjunct questions? Or to put it in more colloquial terms, what goes on in a student's mind when he or she encounters adjunct questions in a text?

There is really little concern with pre-questions, i.e., questions appearing in the text before the paragraphs to which they relate. In encountering a pre-question, the student probably simply makes a mental note of it and continues reading the text. When he or she encounters the particular information related to the question, that information is then probably processed at a deeper level than it would be otherwise. The student pays more attention to the item and possibly rehearses it mentally if the item is a factual item. The pre-question thus serves an orienting role--it labels some information to come as being particularly important and, therefore, especially retention-worthy. The learning of information not related to the pre-question (incidental learning[2]) is possibly not affected by the question, i.e., it is processed to the same extent as it would be if the text had no questions (this is the usual research finding). At times, though, it may be that a pre-question focuses text processing to such an extent that incidental learning may in fact be adversely affected, as is often the case with the use of learning objectives.

Our real concern is with the processes which might be activated by inserted post-questions. Consider the usual experimental situation, where the student is prohibited from looking back at the information item related to a post-question he or she encounters. What happens? Let me speculate. If the question is an easy one, the student probably just answers it mentally and reads on. If the question, on the other hand, is at all difficult, the student probably pauses and tries to mentally recap what was just read, searching his immediate memory for an answer. If the answer is found, the student's later retention of it will be strengthened. The mental search through memory might also strengthen learning of incidental information surrounding the item sought after.

Let me turn now to the most interesting mathemagenic effect, the effect of post-questions on subsequent text processing. This involves an increase in incidental learning ascribed to the gradual shaping of a deeper text processing on the part of the student. The interpretation makes sense: if the student encounters post-questions which he or she has trouble in answering, a likely strategy would be for the student to slow down and process better the information which is being read. For the student knows that there will be further questions and he or she would like to be able to answer them. As Rothkopf has justly stated, "mathemagenic activities are adaptive . . . they can be altered by their consequences" (1970).

That is so, but as was argued in the paper, only inasmuch as the student is not permitted to backtrack! Consider now the student in a naturalistic setting (say a college student reading a textbook) who encounters a post-question in his text. In this situation he can review at will. What is likely to happen? An easy question will simply get a quick

mental response. A difficult question will probably elicit an attempt to mentally recap what was read, with a concomittant potential increase in incidental learning and a strengthening of the answer as well if it is found. If the answer is not forthcoming from memory, the student will most probably backtrack and seek it out in the text.[3] The information related to the question will in either case be better processed than it would have been otherwise. The degree to which incidental information will be more deeply processed will most probably depend on how hard the student mentally searches for the answer to the post-question before giving up and seeking it out in the text. The nature of this search (mental only versus mental and physical), therefore, constitutes the first process difference between the usual experimental situation and the naturalistic one.

The crucial difference, however, relates to the adaptive nature of mathemagenic activities. In a natural setting, will post-questions gradually shape deeper text-processing strategies? I believe the answer to be no. Why not? Quite simply because there is little challenge in it for the student. He knows, of course, that further questions will be encountered, but he also knows that if he gets stuck, he will be able to backtrack and find the answer. There should, therefore, be little concern for him to make the extra effort to process the text more deeply, and hence more slowly if not also more arduously. Incidental learning should, therefore, be no more increased than in a situation without post-questions. At least not because of any shaping phenomenon.

It is here in this strategy trade-off that I believe we find the real difference between the experimental research and naturalistic studying. In the latter setting, post-questions can actually become pre-questions, at least pre-questions to a physical review of the paragraphs related to them.

This indeed is essentially why researchers have instituted the unnatural prohibition to backtrack. The consequence of this, of course, is that their results may be due in a large measure to this experimental artifact, and not as generally supposed to any shaping process of the reading strategies of the students.

Once again, the analysis of mathemagenics just described is highly speculative. If the reader agrees with its logic, however, there should be some concern over the course of this research endeavor in terms of its pedagogical applicability.

I believe the area of questionning during reading to be a highly important one, one which needs to be reconceptualized as it were, as well as being further subjected to empirical scrutiny. While the type of research needed may be difficult to undertake, since naturalistic reading is such a private process, the ecolcgical imperative should always form part of the framework of such research. It is only then that we shall find applicable answers to real problems.

The ecology of question usage.

What I have considered above are possible (and plausible) processing strategies which a learner might typically engage in upon encountering inserted questions in text. It would also be profitable in examining this issue to consider practicalities of using questions as instructional aids, i.e., to examine the issue from the perspective of the instructional designer. After all, very few instructional texts actually make use of inserted questions in a way which parallels their use in the prose passages employed in research.

To be sure, many textbooks employ questions as adjunct learning aids. However, these are usually not inserted in the prose text itself, but rather they appear at the end of chapters. This question usage thus

constitutes a rather different ecology than the one involved in the mathemagenic situation. It gives the questions the character of a quiz, or that of review exercises. It is doubtful that such question usage would have any shaping effect in terms of subsequent text processing.

Another situation in which questions are commonly used is in study guides which accompany textbooks. This, in fact, is merely another variant of the questions-at-end-of chapter form of instructional design, with the same ecology as this latter usage.

One area in which questions are often interspersed in text is in distance-teaching materials. The Open University in Britain, which prepares all of its own instructional materials, makes heavy use of inserted post-questions, which it calls Self-Assessment Questions (SAQs)[4]. The student is requested to mentally construct an answer to them before seeking confirmation as to its correctness. The distinquishing feature of these questions, however, and that which sets them apart ecologically from mathemagenic questions, is the fact that answers to these SAQs generally appear at the end of the text. The student, therefore, need not return to the text to search out an answer. It is doubtful, furthermore, for reasons discussed below, that subsequent text processing is shaped by the consequences of his or her question-answering.

Let us consider processing once again, this time in terms of a functional analysis of adjunct questions. The current concept of comprehension monitoring can be made good use of here.[5] The express purpose of Self-Assessment Questions is to give the student an opportunity to monitor his or her comprehension of the text, and if it is found wanting, to reprocess those parts of it which may need it. The same function is served by end-of-chapter questions and by study guide questions. The aim

is to lead the student to process more deeply those parts of the text which were not sufficiently processed in the first reading of the text. The direction of processing is thus retroactive, and not proactive (i.e., it is a question of re-processing rather than one of deeper processing of subsequent material).

Now it may seem plausible that a student who is not able to answer many of the inserted questions he or she encounters will realize that he or she is simply going too fast (i.e., not processing the text deeply enough). This, in turn, may lead the student to slow down and thus better process subsequent textual material. This may be the case to some extent (which would somewhat vindicate the mathemagenic approach), although I believe it to be largely unlikely.

To understand why, we need to now consider the issue from yet another perspective, that of the student. We need to examine task orientation from the student's point of view and thus consider the ecology of studying. College students study rather differently than school children though, so we need to examine each in turn.

Consider the college student studying a textbook for one of his or her courses. What influences impinge upon his or her study behavior? For one, there is the desire to succeed, i.e., to master the material in the text. This orientation should lead to deep processing, to good comprehension monitoring, and to slower and deeper processing of subsequent material if monitoring reveals inadequate processing. However, there is another big influence on study behavior which can severely limit this first orientation, namely the constraint of time. Study time is usually in short supply for the college student and he or she will often adopt the easiest or quickest strategy of text processing in order to master the material. What would this strategy likely be? Probably an initial pro-

cessing of the text, followed by comprehension monitoring through adjunct questions, followed by making-up for misunderstood information on the basis of the monitoring. In other words, it is simply easier (and more efficient from the student's perspective) to process the text lightly initially and then to go back to it afterwards if need be, than it would be to process the text more deeply. When time is scarce, deep processing becomes a luxury which the student may well feel he or she cannot afford. Thus, the mathemagenic shaping of deeper processing would seem like a theoretical ideal, although one which is probably not realized in practice (other than in artificial experimental situations as was argued in the paper).[6]

What about the school child who is studying a text in class. Here the time constraint is presumably negligable. It may, therefore, be possible that adjunct questions would lead to deeper subsequent processing. I doubt it, however, for school children are poor monitors of their comprehension and probably even poorer strategists. I would guess that if they did use the adjunct questions to monitor their understanding, they would follow the same strategy as that of the older student, i.e., reprocess unlearned parts of text as needed.

Is there not a typcial student, though, say in junior high school, who may study in an ideal manner, i.e., adapt his or her text processing depth of subsequent text as a function of comprehension monitoring? Possibly, although I doubt this type of student would, in fact, be very common.

We are, therefore, left with the following conclusion: what seemed like a good idea on theoretical grounds (the shaping of depth of processing) may well be very impractical in real educational settings.

Designing adjunct questions.

While the tone of the paper, as well as that of this postscript, is very critical of mathemagenic research, it must not be inferred that we should disdain the use of questions in text. Quite to the contrary. It is the theoretical interpretation and its underlying procedural paradigm that I am disagreeing with, not the use of questions as learning aids.

Interest in adjunct questions has largely been due to their indirect effects as revealed in the research, i.e., to their potential to enhance incidental learning. Their direct effects (enhancement of question-related learning) are taken for granted, as indeed they should be. The case I have argued in the paper is that we should seriously question our current belief that we have happened upon this exciting new way to generally enhance learning, as opposed to enhancing it only selectively. In other words, the use of adjunct questions in real settings probably would not enhance incidental learning. This point of view is generally not recognized in the research community and we continue to marvel at the indirect effects of questions.

I believe there is a fundamental misconception here concerning the design of adjunct aids for use in instructional materials. The conception seems to be that if only a sampling of the ideas in a text are questioned, we will nevertheless enhance the learning of many of the other ideas as well, in addition to that of the questioned ideas. Anderson and Biddle (1975) speak of the importance of the indirect effects in these terms, as did Rothkopf in his seminal paper in the area (1970). But why sample? Why not question those ideas which we feel are essential for the student to remember and let him forget the rest?

That may sound like a harsh statement . . . "forget the rest". It does not sound like anything one would recommend if the goal were to optimize

learning in a given situation. That is true if we view learning, as we often do, as the accumulation of knowledge, and indeed as the accumulation of as much of it as is possible. I would suggest that this view is limited.[7] The student is not some kind of storage bin to be filled up with all the information we present to him or her in a text. A better view is that of learning as a selective accumulation of information. In other words, we would like the student to retain the main points of a text, or the facts that we otherwise judge to be important. We really want him or her to selectively process the information in a text. Unselective deeper processing thus becomes non-optimal especially when we consider the constraints of time, as we always must.

It is essentially for selective processing purposes that we provide students with learning objectives (when we do so). It should also be for that reason that we provide students with adjunct questions. Both objectives and inserted questions cue the student as to what to concentrate on, i.e., what to process deeply.

If we accept this selective processing view of optimizing learning in real settings, the enhancement of incidental learning fully loses its perceived importance--in fact it becomes detrimental. It becomes detrimental when we view the student as an individual with some finite capacity within some finite time. Within some period of time, we could have a student learn everything in a text (essential elements and incidental ones as well), or we could have him or her learn only the essential elements within the text and then learn the essential elements in another text. Teaching is selective, and so must be learning.

The instructional designer must thus decide which points in a text are the most important ones and then he should question those. Adjunct questions should have direct effects, not indirect ones.

Research Avenues

Given that most of the past research on inserted questions is suspect in terms of its applicability in real academic settings, and given that research on questions in text is an important research problem, what direction should this research take? A number of possibilities are open to us.

One tempting approach is to examine the ecological problem discussed in the paper directly. This would involve an experimental comparison of post-question effects under the traditional constraints (no backtracking permitted) and under more natural constraints (backtracking permitted). The hypothesis to be tested would be that mathemagenic effects (enhancement of incidental learning) would occur in the first condition, but not in the second. A study along these lines which I conducted myself some months ago was unsuccessful, possibly due to a lack of experimental control. The study failed to find mathemagenic effects in either condition and no comparison can therefore be made.[8] The case, therefore, remains to be made empirically. Such a study would certainly inform the main issue discussed in the paper (by either supporting the argument or contradicting it).

Another research approach, one which is much more important I feel, is to examine reading and study behaviors of students as they process text. The challenge, of course, is to devise ways in which this can be done unobtrusively, without disturbing or artificializing the processes being examined. We need to find out how students actually go about processing text, what they do when they encounter an inserted question, and so on. Attempts in this direction appear to be few and still relatively unsophisticated. Devices which monitor a student's reading activity, such as the reading recorder developed in Britain (Thomas and Augstein, 1972; Whalley and Fleming, 1975) may show promise if further developed. Computer

presentation of text on a video terminal may also be appropriate (e.g., Alessi, Anderson, and Goetz, 1979), as might also be eye-movement monitors. The task before us is to find ways to monitor reading activities without drastically changing the ecology of the situation.

Yet another approach is to get student reactions to their use of questions in text. This could be done either through surveys or debriefing interviews following reading. Examples of the survey approach are studies by Nathenson (1978) and Duchastel and Whitehead (1979), which attempted to find out the extent to which Open University students in Britain actually made use of the Self-Assessment Questions they encountered in their texts. The danger of this approach, of course, is that students may not themselves in fact know what they do, even though they may feel that they do know. Examining one's own reading strategies is a demanding task. I, nevertheless, feel that getting the student's view should be an important aspect of the research on questions. Not only what a student does, but why he or she does it, can certainly assist in helping us explain what is going on during reading.

In conclusion, the rigorous approach which constitutes the experimental studies of adjunct questions needs to be complemented by the less reliable but more insightful one offered by observation and analysis. The misdirection of adjunct question research discussed in the paper would seem to certainly support such a view.

Finally, we need to further critically review the assumptions about learning which underpin our research strategies. If a view of learning as selective processing is favored, then we should perhaps emphasize research on the direct effects of questions (as Anderson and Biddle, 1975, have done) and be less concerned with their indirect effects.

Postscript footnotes:

1. The initial paper was written while I was at the Open University in Great Britain.
2. Incidental learning is a technical term commonly used to refer to the learning of information not related to an adjunct aid such as a learning objective or an adjunct question. Its incidental status is only technically ascribed and need not correspond to a lower level of actual importance in the text. This issue is explored later on in the postscript.
3. An assumption made here, of course, is that the question is perceived as important, otherwise it will simply be skipped, and not recalled later on.
4. It also sometimes makes use of what are labelled In-Text Questions (ITQs). These are generally questions which either expand on the subject matter or attempt to increase student motivation by getting the student to think out some problem prior to the discussion of it in the text. They, therefore, share some of the character of pre-questions, although they are probably better thought of as rhetorical questions which are explicitly labelled.
5. Rehearsal monitoring is another form of monitoring where the information to be learned is factual information. The present analysis applies to both comprehension and rehearsal monitoring, although I shall refer solely to the former in this discussion for the sake of brevity.
6. The situation would be even further complicated if we considered other influences on study behavior, such as interest in the topic, the perceived relevance of the questions, etc.
7. The parallel to the idea of sampling in test construction is evident here. The conception works fine in testing (within limits), but not well in learning.

8. The report of this study, entitled Mathemagenics and Review Constraints, is available in mimeograph form from the author.

Postscript References
(additional to those in the paper)

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